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CableTest Technical Bulletin

Mass HiPot Testing

Mass HiPot is a methodology where multiple wires (or nets) are grouped together to the high side (output) of the instrument and get energized simultaneously while the others are grouped to the low side (input) of the instrument...

Introduction:

HiPot testing is a method of testing wires, cables and harnesses wherein a high voltage, low current, AC or DC signal is applied to each of the tested nets. The typical purpose is to test the insulation resistance, the breakdown characteristics of insulating materials, or both.

Linear HiPot:

Traditionally, HiPot testing is performed by energizing one conductor (or net) at a time and grounding all other nets. If there is a high voltage breakdown, it is clearly between the energized net and at least one of the other nets. While this method conclusively detects all HiPot testing faults, it requires a separate test for each net and can be very time consuming.

A diagram of the traditional testing method for a seven-net cable is shown in Table 1 (Note: each net may contain multiple points).

	Test Number						
Conductor	1	2	3	4	5	6	7
1	+	-	-	-	-	-	-
2	-	+	-	-	-	-	-
3	-	-	+	-	-	-	-
4	-	-	-	+	-	-	-
5	-	-	-	-	+	-	-
6	-	-	-	-	-	+	-
7	-	-	-	-	-	-	+

Table 1 - Linear HiPot Algorithm

Legend:
"+" = High Voltage, "-" = Grounded

As demonstrated above, seven tests are required to test all seven nets. Therefore, the time required to HiPot test assemblies in this fashion is directly related to the number of nets or wires to be tested and can be represented by:

$$Time = N * D$$

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Where:

N = number of nets to be HiPot tested
D = dwell time per net.

If we assume that there are 500 nets, the test time will be 8.3 hours, assuming a 1-minute dwell for each net. It is common to have a dwell of at least 10 seconds, and even at 10 seconds of dwell per test, the test time would be 1.4 hours.

Mass HiPot:

A major advantage of the CableTest product line is the ability to Mass HiPot wired assemblies. Mass HiPot is a methodology where multiple wires (or nets) are grouped together to the high side (output) of the instrument and get energized simultaneously while the others are grouped to the low side (input) of the instrument. A CableTest exclusive algorithm then changes the make up of the high side and low side groups in such a manner that, after the test is completed, each wire is guaranteed to have seen the opposite polarity against all other wires. In this manner, the results are as complete and as valid as in more traditional testing, but testing occurs much more rapidly.

The un-optimized Mass HiPot algorithm is conceptually illustrated in Table 2 (Note: in real life, the generated patterns will be different as the algorithm performs a number of optimizations).

	Test Number		
Conductor	1	2	3
1	-	-	+
2	-	+	-
3	-	+	+
4	+	-	-
5	+	-	+
6	+	+	-
7	+	+	+

Table 2 - Mass HiPot Algorithm

Notice that after the 3 test phases, all conductors have been checked at opposite potentials to all others. Thus, the formula for the number of test phases required is:

$$N = [\log_2 (C)]$$

Where:

C = the number of nets being tested
N = number of test phases required
[ ] = Rounds to closest higher integer

The formula for the time required is:

$$Time = N \times D$$

Determining Test Speed:

The Mass HiPot algorithm's ability to improve test speed is illustrated in Table 3 using 7, 30 and 500 -conductor harnesses as examples.

	No. Of Tests		1 min. Dwell		10 sec Dwell	
# Of	Standard	Mass	Standard	Mass	Standard	Mass
Nets	HiPot	HiPot	HiPot	HiPot	HiPot	HiPot
7	7	3	7 min.	3 min.	70 secs	30 secs
30	30	5	30 min.	5 min.	5 min.	50 secs
500	500	9	8.3 hrs	9 min.	1.4 hrs	90 secs

Table 3 - Linear vs. Mass HiPot Testing

Although the Mass HiPot method provides the greatest benefit for large cables and harnesses, it can be twice as fast for small cables. Table 3 demonstrates that by using the Mass HiPot method for 30 nets, only 5 HiPot tests would be required instead of 30. For 500 nets, only 9 HiPot tests are required. The standard HiPot method would take 8.3 hours to test 500 nets - assuming a 1-minute dwell time per conductor.

If Arc Is Detected:

If an arc is detected in one of the test phases, the algorithm can break down the grouping in a binary fashion until it isolates the fault(s) or it can revert to a single conductor scan. The actual nets that are causing the arc will be identified in the error log.

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Note: in certain cases, an arc may not repeat, or the condition might be "self-healing". One example might be where a very thin whisker touching an adjacent conductor or shield causes the high voltage short.

When the high voltage is applied, the whisker will vaporize, thereby removing the condition. Since the Mass HiPot algorithm uses a re-scan technique to locate the exact location of the fault, in these types of situations, the Horizon or MPT will not be able to exactly locate the fault and the diagnostics will simply indicate "Arc During Mass HiPot."

Mass HiPot Implications:

CableTest has been performing Mass HiPot tests for many years, and while the implementation may seem simple, there are some significant considerations:

1. When HiPot testing single conductors, the capacitance of the charged cable contains the entire energy output of the supply. If an arc occurs, the energy transmitted back to the source does not exceed the capacitive charge held by that one conductor.

2. When HiPot testing in mass mode, many conductor paths are energized in parallel and the stored energy is additive. If an arc occurs, the return path must be capable of handling the extra instantaneous current.

To solve these problems, CableTest designed specific high voltage switch modules to incorporate a high current buffer stage in series with the high voltage output. Therefore, our switching is able to withstand the current spikes that may be generated with Mass HiPot applications

IR (Leakage) Failures:

Mass HiPot will also report IR (leakage) failures. However, care should be taken in setting the leakage limit since the total leakage is the sum of the leakages for all of the conductors in a group.

For example, if you have a cable with 8 nets, and you wanted to test for leakage at 100 µA, you would program the Horizon or MPT to that value. The largest group of nets set up by Mass HiPot for the example cable would be 4. If each wire leaked at about 40 µA, the total leakage experienced by the group would be 160 µA, and the Horizon or MPT might fail the cable. To prevent an erroneous failure, in this situation, Mass HiPot automatically falls back to a smaller group size if it sees a failure in a large group. In this manner, it helps insure that it will not fail a good cable, but the test will be slower. Keep this in mind when setting your leakage limits.

Test Application Coverage:

The MPT and Horizon test systems allow both the traditional HiPot and the Mass HiPot tests as user programmable options. This gives the user unparalleled flexibility in selecting the most appropriate testing method for their product.

About CableTest Systems Inc.

CableTest Systems Inc. provides total cable testing solutions to a wide array of industries including aerospace, computers, medical, telecommunications, transportation and the military. Customers rely on CableTest's high voltage interconnect equipment to test their cables, wiring harnesses, power cords, and backplanes with speed, accuracy and reliability. You can learn more about CableTest Systems Inc. at www.CableTest.com.

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